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Maximum Amplification of Enstrophy in 3D Navier-Stokes Flows[1] BARTOSZ PROTAS, DI KANG, DONGFANG YUN, McMaster University — This investigation concerns a systematic search for potentially singular behavior in 3D Navier-Stokes flows. Enstrophy serves as a convenient indicator of the regularity of solutions to the Navier Stokes equation — as long as this quantity remains finite, the solutions are guaranteed to be smooth and satisfy the equations in the classical (pointwise) sense. However, there are no finite a priori bounds available for the growth of enstrophy and hence the regularity problem for the 3D Navier-Stokes system remains open. To quantify the maximum possible growth of enstrophy, we consider a family of PDE optimization problems in which initial conditions with prescribed enstrophy $\mathcal{E}_\prime$ are sought such that the enstrophy in the resulting Navier-Stokes flow is maximized at some time T. Such problems are solved computationally using a large-scale adjoint-based gradient approach. By solving these problems for a broad range of values of T and $\mathcal{E}_\prime$, we demonstrate that the maximum growth of enstrophy appears finite and scales in proportion to $\mathcal{E}_\prime^{\ni/\in}$. Thus, in the worst-case scenario the enstrophy remains bounded for all times and there is no evidence for formation of singularity in finite time.

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